Energy Change

Chapter 5

The Nature of Energy

Part 2

Last Class

- Energy
- Thermochemistry
- Transfer of Energy
- Systems and Surroundings
- Heat (Q)

Outline

- Thermodynamics
- Enthalpy
- Physical change
- Chemical change
- Nuclear change

Thermodynamics

- Thermodynamics- study of energy and its transfers

- First Law of Thermodynamics- (law of conservation of energy) the energy of a system remains constant and therefore, energy cannot be created nor destroyed; it can only be transformed from one form to another. ($E_{system} = -E_{environment}$)
- Second Law of Thermodynamics- a law stating that when two objects are in thermal contact, heat is always transferred from the object at a higher temperature to the object at a lower temperature until the two objects are at the same temperature.

Enthalpy

- Definition: $H \equiv E + PV$
- Since E, P and V are all state functions, then H is too
- For the following, the process is at constant P and the only type of work allowed is PV work

so, $q_P = \Delta H$ at constant P

Enthalpy

- Heat of reaction and change in enthalpy are used interchangeably for a reaction at constant P

$\Delta H = H_{products} - H_{reactants}$

endo: $+ \Delta H$ exo: $- \Delta H$

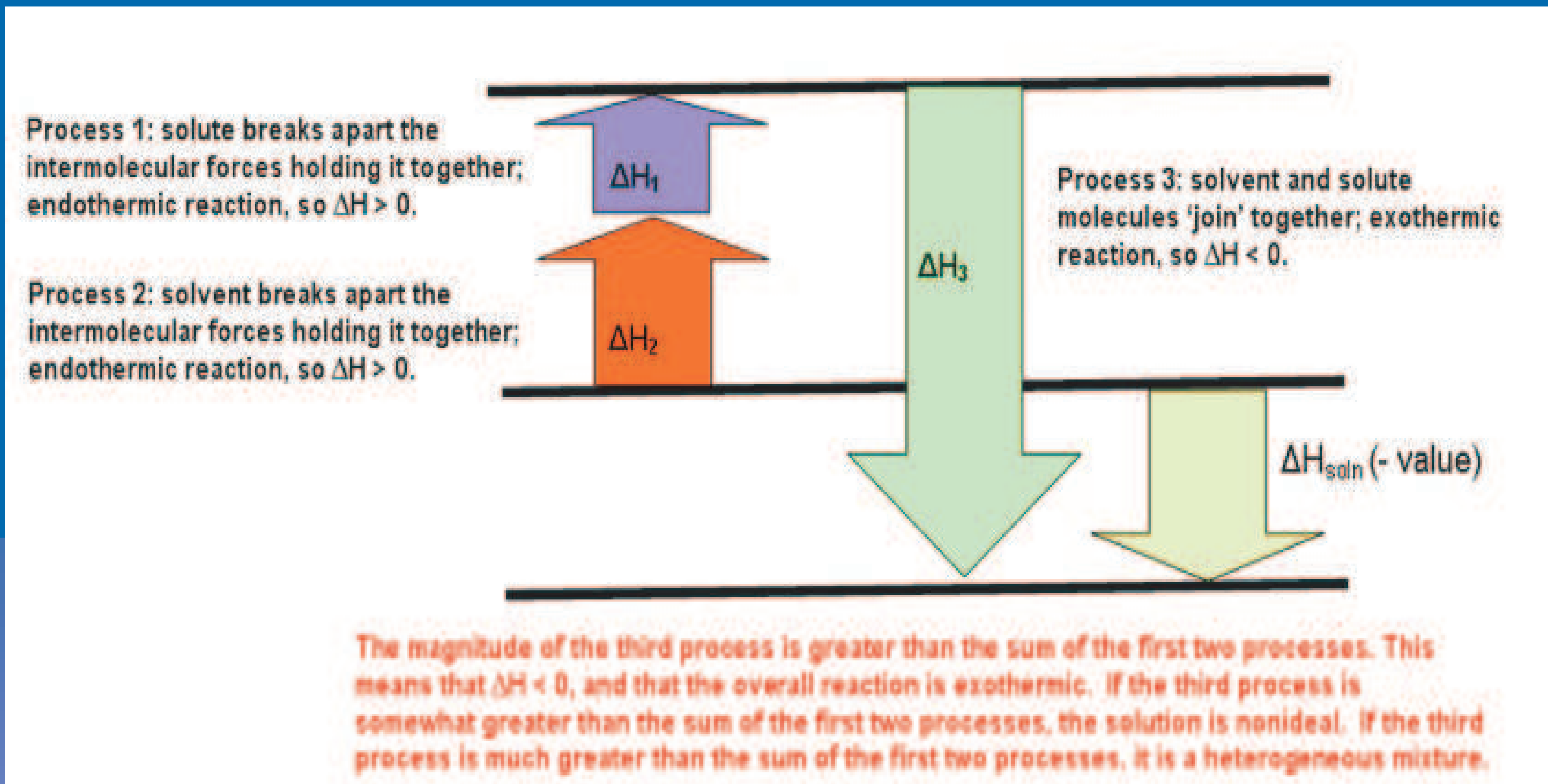
Enthalpy of Solution

- Enthalpy of Solution ($\Delta H_{solution}$)- the enthalpy change associated with a solute dissolving in a solvent.

- Three steps, each involving an enthalpy change that must occur for a solute to become dissolved in water or in another solvent:

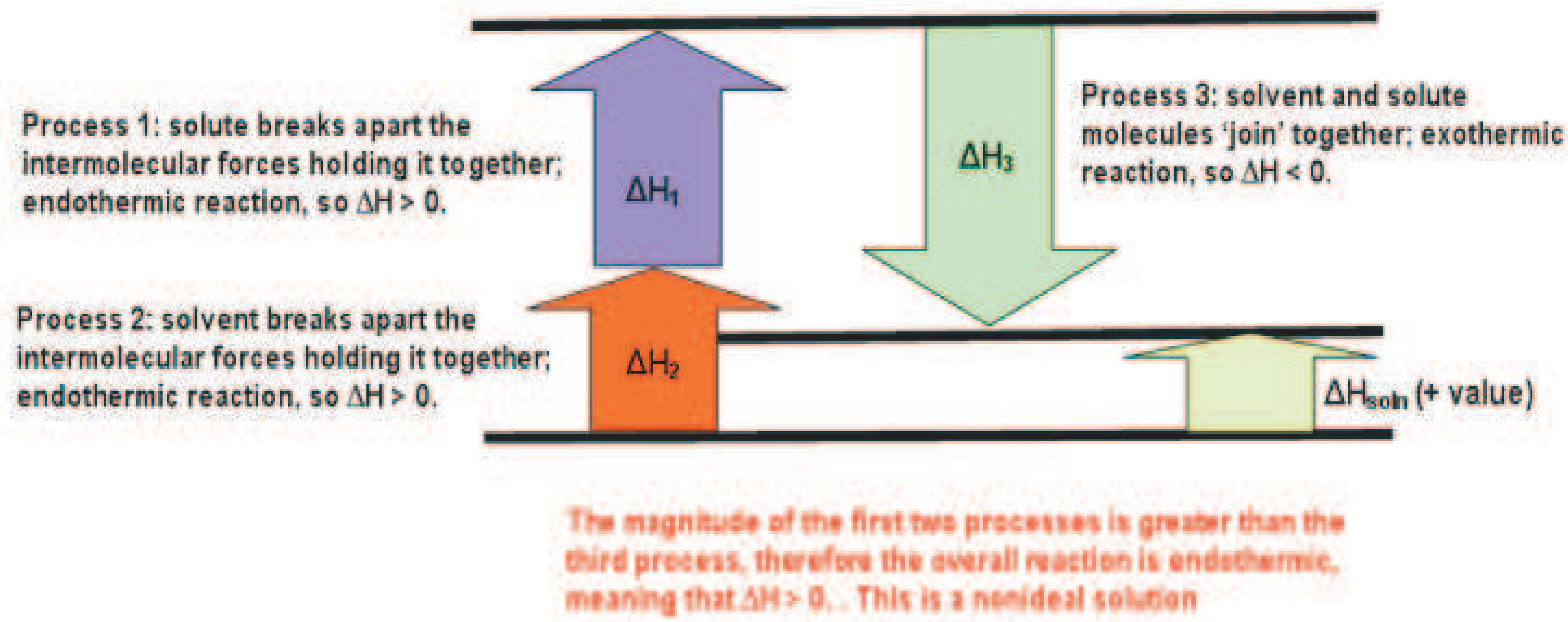
1) Bonds between molecules/ions of a solute must be broken to make room for the solute molecules
2) Bonds between solvent molecules must be broken to make room for the solute molecules
3) Bonds must form between the solvent molecules and solute molecules or ions (i.e., intermolecular, ionic, dipole-dipole, etc.)

Exothermic Energy Diagram



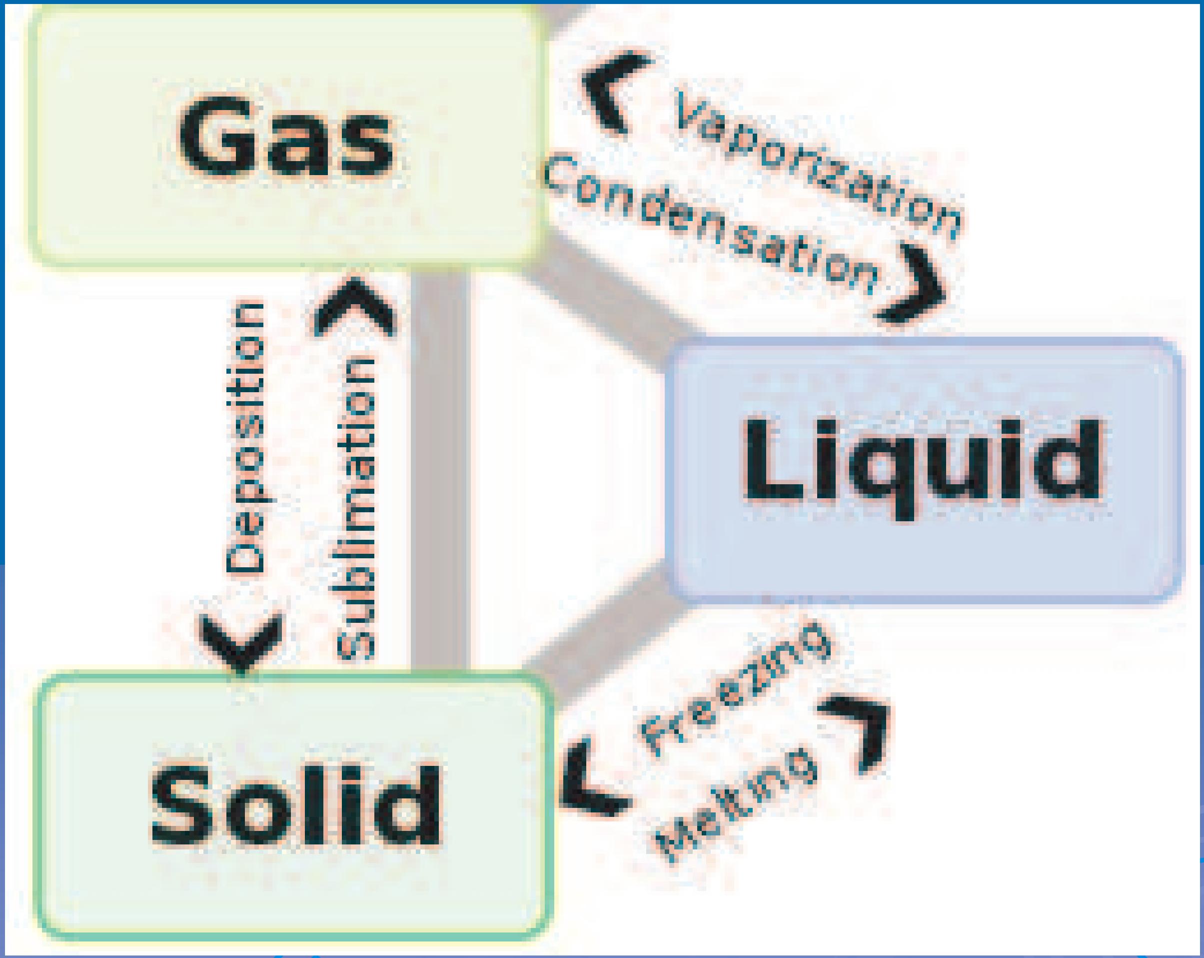
*dissolving process ($\Delta H_{sol} < 0$)

Endothermic Energy Diagram



*dissolving process (ΔHsol > 0)

Enthalpy of Phase Changes



Physical Change

- Two physical changes in a system that are associated with significant changes in the enthalpy of a system

1. Dissolving one substance into another
2. Phase change

Chemical Change

- A chemical change results in the formation of a new substance(s) with different physical and chemical properties than the initial substance(s)

- Examples:
  - Adding Alka-Seltzer to water will produce a gas.
  - Combustion
  - Potassium to water

Indicators of Chemical Reaction

- Change in colour
- Heat is released (exothermic)
- Heat is absorbed (endothermic)
- Light produced
- Precipitate is formed
- Gas is produced
- Change in smell

Nuclear Change

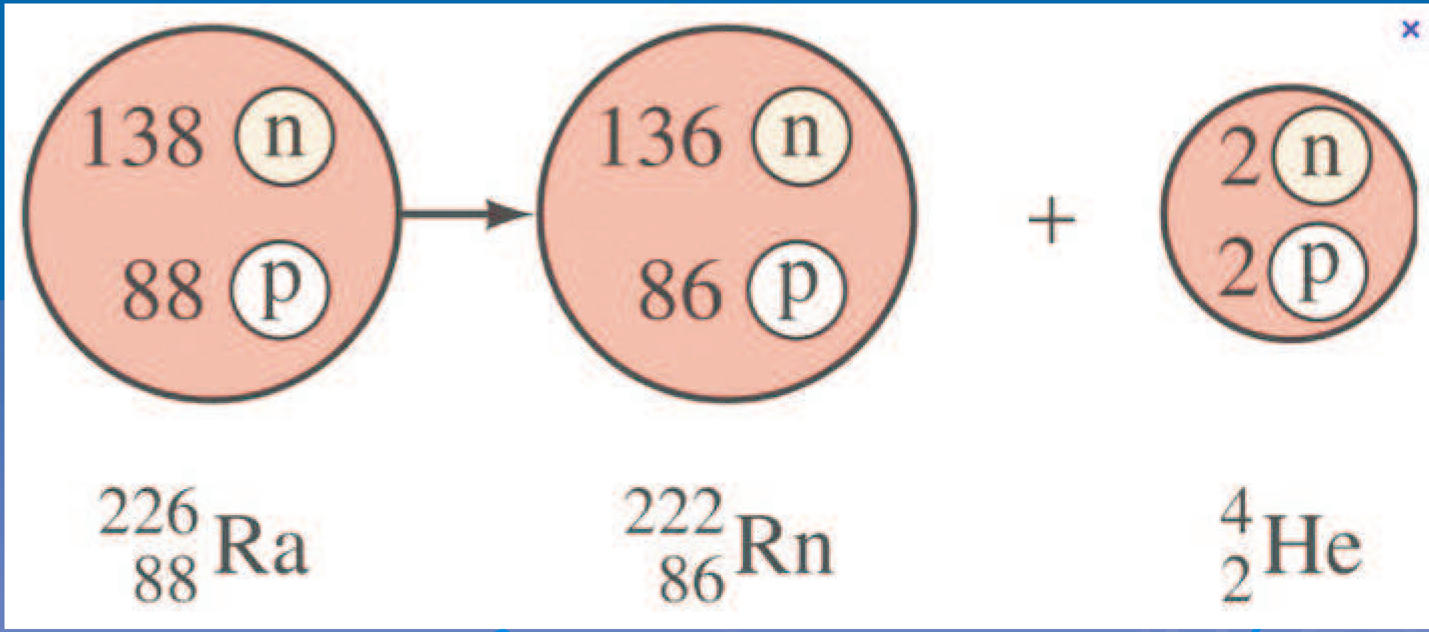
- Atoms spontaneously emit particles from their nuclei and are transformed into other elements

- Two Types:

1. Alpha decay (penetrating power→ stopped by paper)
2. Beta decay (penetrating power→ stopped by a few cm of water or wood)

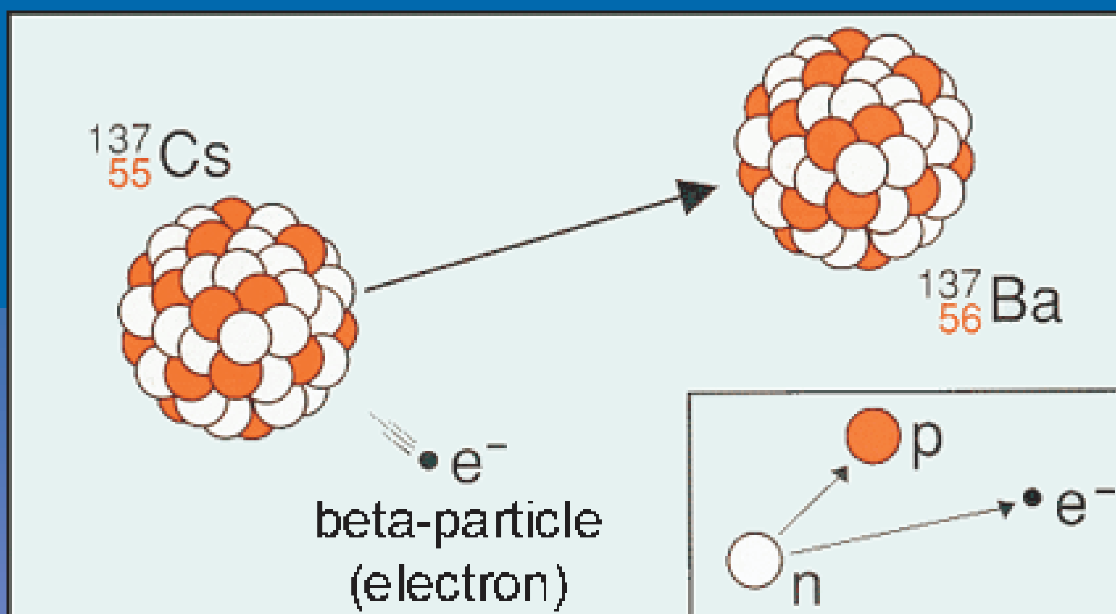
Alpha Decay

- Nucleus emits an alpha (α) particle
- Resulting nucleus has two fewer protons and two fewer neutrons



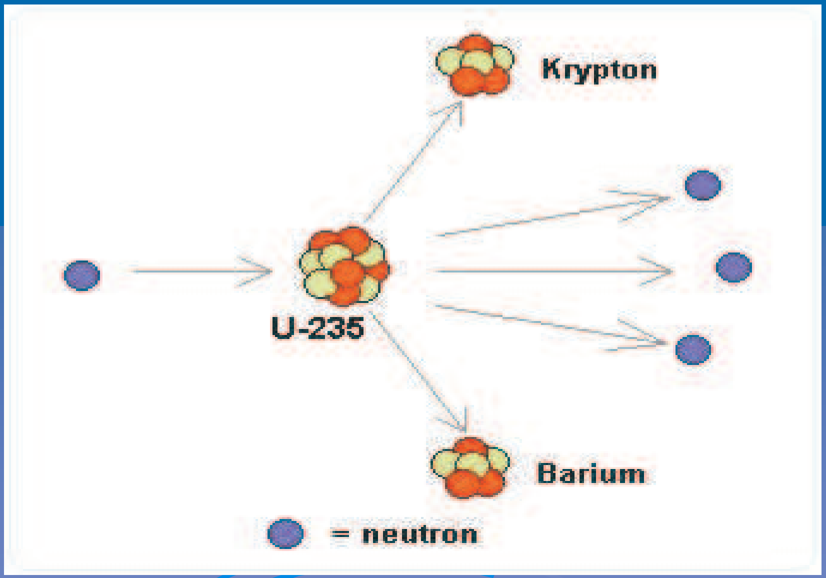
Beta Decay

- Nucleus emits a beat (β) particle
- A neutron in the nucleus becomes a proton



Nuclear Fission

- Process in which a heavier nucleus splits into smaller, lighter nuclei with the release of energy



Albert Einstein

$$E = mc^2$$

E = energy released during a nuclear reaction

m = mass (kg)

c = light constant (3.00×10^8 m/s)

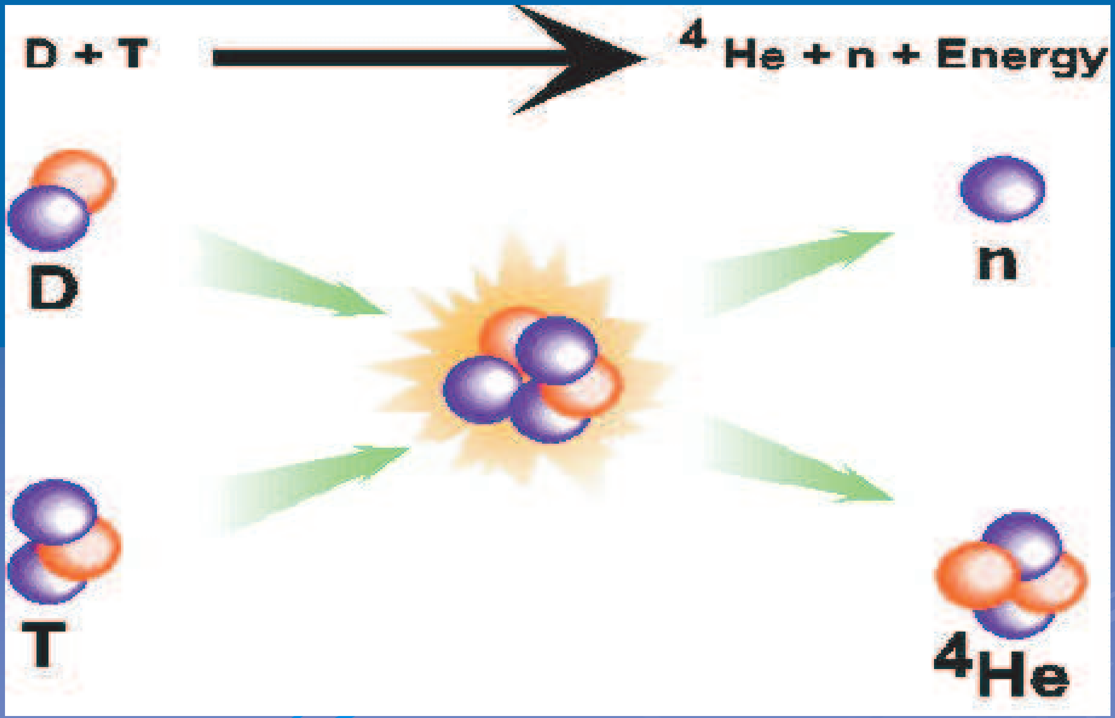
- This equation allows you to determine how much energy is released during nuclear fission

Using Einstein's Formula

1) When 1 mol of uranium-235 fissions, the amount of mass that is converted into energy is 2.15×10^{-4} kg. calculate the amount of energy released when 1 mol of uranium-235 fissions.

Nuclear Fusion

- Two very small nuclei combine, or fuse, to form a slightly larger nucleus
- Occurs in the sun



Nuclear Reaction Examples

Complete the following reactions:

1. What is the missing product in the following equation?

$$^{253}_{98}Cf \longrightarrow ^{253}_{99}Es + \square$$

   a. Electron (also known as a beta particle)
   b. Proton
   c. Neutron
   d. Alpha particle

2. What is the missing product in the following equation?

$$^{253}_{100}Fm \longrightarrow ^{4}_{2}He + \square$$

3. What is the missing reactant in the following equation?

$$\square \longrightarrow ^{0}_{-1}\acute{e} + ^{120}_{50}Sn$$

Range of ΔH for Reactions

Type of Change	Range of ΔH Values (kJ/mol)	Example
Physical	±0.44 to ± 40.7	-Heat absorbed during division of one bacterial cell - Average kinetic energy of a molecule
Chemical	±196.4 to ± 890	-Combustion of glucose -TNT exploded -1kW(h) of electrical energy
Nuclear	-1.13×10^{8} to -2×10^{10}	-Daily solar energy falling on Earth -Energy of a strong earthquake -Daily output of Niagara Falls dam

Homework

- Readings page 282-291
- Page 291 #3, 8, 10, 11